

## Permissible Exposure Level for Lunar Dusts: Gaps are Closing

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Space faring nations plan to return human explorers to the moon within the next decade. Experience during the Apollo flights suggests that lunar dust will invariably get into the habitat where the finest portion ( $<5 \mu\text{m}$ ) could be inhaled by the crew before it is cleared from the atmosphere. NASA is developing a database from which a 6-month, episodic exposure standard for lunar dust can be set.

Three kinds of moon dust were prepared from a parent sample of Apollo 14 regolith #14003,96. Our goal was to prepare each type of dust sample with a mean diameter less than  $2 \mu\text{m}$ , which is suitable for instillation into the lungs of rats. The three samples were prepared as follows: separation from the parent sample using a fluidized bed, grinding using a jet mill grinder, or grinding with a ball-mill grinder. Grinding simulated restoration of surface activation of dust expected to occur at the surface of the moon on native lunar dust. We used two grinding methods because they seemed to produce different modes of

activation. The effects of grinding were preserved by maintaining the dust in ultra-pure nitrogen until immediately before it was placed in suspension for administration to rats.

The dust was suspended in physiological saline with 10% Survanta®, a lung surfactant. Rats were given intratracheal instillations of the dust suspension at three doses. In addition to the three moon dusts (A, C and E), we instilled the same amount of a “negative” control ( $\text{TiO}_2$ , B) and a highly-toxic, positive control (quartz, D). These

additional mineral dusts were selected because they have well-established and very different permissible exposure levels (PELs). Our goal was to determine where lunar dusts fit between these extremes, and then estimate a PEL for each lunar dust. We evaluated many indices of toxicity to the lung. The figure shows the changes in lactate dehydrogenase (LDH), a marker of cell death, for the five dusts. Benchmark dose software (Version 2.1.2) from the Environmental Protection Agency was used to estimate the 10% effect levels ( $\text{BMD}_{10}$ ) using five models. The best-fitting model was used to estimate the optimal  $\text{BMD}_{10}$  (table) for each of the lunar samples. We have many more indices of toxicity to analyze before we settle on a

LDH				
	$\text{BMD}_{10}$	$\text{Log}_{\text{BMD}_{10}}$	“PEL” ( $\text{mg}/\text{m}^3$ )	$\text{Log}_{\text{PEL}}$
D	0.004615	-2.34	0.05	-1.30
E	0.03771	-1.42	0.71	-0.15
A	0.03828	-1.42	0.72	-0.14
C	0.07537	-1.12	1.36	0.13
B	0.3038	-0.52	10.00	1.00

provisional PEL for each of the three lunar dusts. At this point it appears that the PELs will be about the same for each type of dust. The initial set of data will be based on instilled dust and biomarkers in lung lavage fluid. These data will be integrated with results from histopathology on the lungs of rats instilled with the dusts. Finally, an inhalation study will be conducted on one of the dusts to more realistically simulate exposures in a lunar habitat.

